

## CLAIMS

What is claimed is:

1. A method of garbage collection and scheduling performed at individual  
5 nodes of a processing graph comprising the steps of:  
  
based on forward guarantees received from preceding nodes  
indicating earliest timestamps to be sent from the preceding nodes, and  
backward guarantees received from successive nodes indicating earliest  
timestamps to be used at the successive nodes, determining timestamp  
10 requirements for data to be processed in the node;  
  
returning to preceding nodes a backward guarantee of earliest  
timestamps to be used at the node; and  
  
at the preceding nodes, eliminating data and computations  
corresponding to timestamps earlier than the backward guarantee.  
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2. The method as claimed in Claim 1 further comprising the step of:  
  
propagating a forward guarantee to successive nodes based on  
forward guarantees received from preceding nodes each time an item leaves  
the node.  
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3. The method as claimed in Claim 2 wherein the propagated forward guarantee  
is the earliest of all the received forward guarantees.



4. The method as claimed in Claim 2 wherein a forward guarantee for the node is forwarded to a downstream node with the item.
5. The method as claimed in Claim 1 further comprising the step of:  
5                      periodically propagating a forward guarantee to successive nodes  
                         based on forward guarantees received from preceding nodes.
6. The method as claimed in Claim 1 further comprising the step of:  
                         propagating the backward guarantee to preceding nodes each time an  
10                      item enters the node.
7. The method as claimed in Claim 6 wherein the backward guarantee is the  
                         timestamp selected from the latest timestamp received from preceding nodes  
                         and the earliest timestamp in received backward guarantees from successive  
15                      nodes.
8. The method as claimed in Claim 1 wherein the preceding node is a thread.
9. The method as claimed in Claim 8 further comprising the step of:  
20                      eliminating computations for items having a timestamp earlier than  
                         the latest backward guarantee propagated to the preceding node.
10. The method as claimed in Claim 1 wherein the preceding node is a channel.



11. The method as claimed in Claim 10 further comprising the step of:  
  
eliminating items having a timestamp earlier than the latest backward guarantee propagated to the preceding node.
- 5 12. The method as claimed in Claim 11 wherein the step of eliminating is performed each time an item enters the channel.
13. An apparatus in individual nodes of a processing graph which performs garbage collection and scheduling comprising:  
  
10 a propagation routine which determines time-stamp requirements for data to be processed in the node based on forward guarantees received from preceding nodes indicating earliest time-stamps to be sent from the preceding nodes and backward guarantees received from successive nodes indicating earliest time-stamps to be used at the successive nodes; and  
  
15 a backward guarantee of the earliest time-stamp to be used at the node, the backward guarantee returned to preceding nodes and used at the preceding nodes to eliminate data and computations corresponding to time-stamps earlier than the backward guarantee.
- 20 14. The apparatus as claimed in Claim 13 wherein the propagation routine propagates a forward guarantee to successive nodes based on forward guarantees received from preceding nodes each time an item leaves the node.
15. The apparatus as claimed in Claim 14 wherein the propagated forward  
25 guarantee is the earliest of all the received forward guarantees.



16. The apparatus as claimed in Claim 13 wherein the propagation routine periodically propagates a forward guarantee to successive nodes based on forward guarantees received from preceding nodes.
- 5 17. The apparatus as claimed in Claim 13 wherein the propagation routine propagates the backward guarantee to preceding nodes each time an item enters the node.
- 10 18. The method as claimed in Claim 17 wherein the backward guarantee is the timestamp selected from the latest timestamp received from preceding nodes and the earliest timestamp in received backward guarantees from successive nodes.
- 15 19. The apparatus as claimed in Claim 13 wherein the preceding node is a thread.
20. The apparatus as claimed in Claim 19 wherein the propagation routine eliminates computations for items having a timestamp earlier than the latest backward guarantee propagated to the preceding node.
- 20 21. The apparatus as claimed in Claim 13 wherein the preceding node is a channel.
- 25 22. The apparatus as claimed in Claim 21 wherein the propagation routine eliminates items having a timestamp earlier than the latest backward guarantee propagated to the preceding node.



23. The apparatus as claimed in Claim 22 wherein the propagation routine eliminates items each time an item enters the channel.
24. The apparatus as claimed in Claim 14 wherein the propagation routine forwards a forward guarantee for the node to a downstream node with the item.
25. An apparatus in individual nodes of a processing graph which performs garbage collection and scheduling comprising:
- means for propagating which determines timestamp requirements for data to be processed in the node based on forward guarantees received from preceding nodes indicating earliest timestamps to be sent from the preceding nodes and backward guarantees received from successive nodes indicating earliest timestamps to be used at the successive nodes; and
- a backward guarantee of the earliest timestamp to be used at the node, the backward guarantee returned to preceding nodes and used at the preceding nodes to eliminate data and computations corresponding to timestamps earlier than the backward guarantee.
26. The apparatus as claimed in Claim 25 wherein the means for propagating propagates a forward guarantee to successive nodes based on forward guarantees received from preceding nodes each time an item leaves the node.
27. The apparatus as claimed in Claim 26 wherein the propagated forward guarantee is the earliest of all the received forward guarantees.



28. The apparatus as claimed in Claim 25 wherein the means for propagating periodically propagates a forward guarantee to successive nodes based on forward guarantees received from preceding nodes.
- 5 29. The apparatus as claimed in Claim 25 wherein the means for propagating propagates the backward guarantee to preceding nodes each time an item enters the node.
- 10 30. The method as claimed in Claim 29 wherein the backward guarantee is the timestamp selected from the latest timestamp received from preceding nodes and the earliest timestamp in received backward guarantees from successive nodes.
- 15 31. The apparatus as claimed in Claim 25 wherein the preceding node is a thread.
- 20 32. The apparatus as claimed in Claim 31 wherein the means for propagating eliminates computations for items having a timestamp earlier than the latest backward guarantee propagated to the preceding node.
33. The apparatus as claimed in Claim 25 wherein the preceding node is a channel.



34. The apparatus as claimed in Claim 33 wherein the means for propagating eliminates items having a timestamp earlier than the latest backward guarantee propagated to the preceding node.
- 5 35. The apparatus as claimed in Claim 34 wherein the means for propagating eliminates items each time an item enters the channel.
36. The apparatus as claimed in Claim 25 wherein the means for propagating forwards a forward guarantee for the node to a downstream node with the  
10 item.